



Cambridge International AS & A Level

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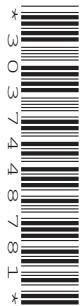
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CHEMISTRY

9701/36

Paper 3 Advanced Practical Skills 2

October/November 2024

2 hours

You must answer on the question paper.

You will need: The materials and apparatus listed in the confidential instructions

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 40.
- The number of marks for each question or part question is shown in brackets [].
- The Periodic Table is printed in the question paper.
- Important values, constants and standards are printed in the question paper.
- Notes for use in qualitative analysis are provided in the question paper.

Session
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

This document has 12 pages.



Quantitative Analysis

Read through the whole method before starting any practical work. Where appropriate, prepare a table for your results in the space provided.

Show the accuracy of the apparatus you used in the data you record.

Show your working and appropriate significant figures in the answer to **each** step of your calculations.

1 Sodium carbonate reacts with hydrochloric acid to release carbon dioxide as shown.



You will find the percentage purity in a sample of impure sodium carbonate by reacting it with excess hydrochloric acid and measuring the volume of carbon dioxide formed. You may assume that the impurity does not react with acid to produce a gas.

FB 1 is impure sodium carbonate, Na_2CO_3 .

FB 2 is hydrochloric acid, HCl .

(a) Method

- Weigh the container with **FB 1**. Record the mass.
- Fill the tub with water to a depth of approximately 5 cm.
- Fill the 250 cm^3 measuring cylinder completely with water. Holding a piece of paper towel firmly over the top, invert the measuring cylinder and place it in the water in the tub.
- Remove the paper towel and clamp the inverted measuring cylinder so the open end is in the water just above the base of the tub.
- Use the 50 cm^3 measuring cylinder to transfer 50.0 cm^3 of **FB 2** into the flask labelled **X**. Check the bung fits tightly into the neck of flask **X**, clamp flask **X** and place the delivery tube into the inverted 250 cm^3 measuring cylinder.
- Remove the bung from the neck of the flask. Tip all the **FB 1** into the acid in the flask and replace the bung immediately. Remove the flask from the clamp and swirl it to mix the contents.
- Replace the flask in the clamp and leave until the fizzing has stopped.
- Remove the flask from the clamp occasionally, swirl it and replace the flask in the clamp.
- Weigh the empty container that held **FB 1**. Record the mass.
- Calculate and record the mass of **FB 1** added.
- When no more gas is collected, record the final volume of gas produced.

You may wish to start Question 2 while the gas is being produced.

Results

I	
II	
III	
IV	

[4]





(b) Calculations

(i) Give your answers to each part of (b)(ii), (b)(iii) and (b)(iv) to an appropriate number of significant figures.

[1]

(ii) Calculate the amount, in mol, of carbon dioxide collected in the 250cm^3 measuring cylinder.

amount of CO_2 = mol [1]

(iii) Use your answer to (b)(ii) to deduce the amount, in mol, of the sodium carbonate present in the **FB 1** you used in your experiment.

amount of Na_2CO_3 = mol

Use your answer to calculate the mass, in g, of sodium carbonate in your sample of **FB 1**.

mass of Na_2CO_3 = g
[1]

(iv) Calculate the percentage purity of **FB 1**.

percentage purity = % [1]





(c) Even though the bung was replaced quickly, some carbon dioxide was lost. Suggest a change you could make to minimise gas loss at this stage.

.....
.....
.....

[1]

(d) Some carbon dioxide is not collected because it is slightly soluble in water. State a change you could make to reduce the solubility of the gas.

Do not suggest using a liquid other than water in your tub or changing the volume of water used.

.....
.....
.....

[1]

(e) State the uncertainty in a single reading of your balance.

uncertainty = \pm g

Calculate the maximum percentage error in the mass of **FB 1** used in (a).

maximum percentage error = %
[1]

[Total: 11]





2 Many metal carbonates, such as magnesium carbonate, decompose to form the metal oxide when heated.



Other metal carbonates, such as sodium carbonate, Na_2CO_3 , do not decompose at the temperature produced by a Bunsen burner.

FB 3 is a mixture that contains only sodium carbonate, Na_2CO_3 , and magnesium carbonate.

You will carry out an experiment involving thermal decomposition to find the percentage of each of these metal carbonates in this mixture.

(a) Method

- Weigh the empty crucible with its lid. Record the mass.
- Transfer all the **FB 3** from the container into the crucible.
- Weigh the crucible, lid and **FB 3**. Record the mass.
- Calculate and record the mass of **FB 3** used.
- Place the crucible and contents on the pipe-clay triangle.
- Heat the crucible gently, with the lid on, for approximately 1 minute.
- Heat strongly, with the lid off, for a further 5 minutes.
- Leave the crucible with its contents until it is cool.

While the crucible is cooling, you may wish to begin work on Question 3.

- When the crucible is cool, weigh the crucible with its lid and contents. Record the mass.
- Heat the crucible strongly, with the lid off, for approximately 4 minutes.
- Allow the crucible and contents to cool.
- When the crucible is cool, weigh the crucible with its lid and contents. Record the mass.
- Calculate and record the mass of residue.
- Calculate and record the mass of carbon dioxide produced.

Leave the crucible and contents to become completely cool for use in Question 2(c).

Results

I	
II	
III	
IV	
V	

[5]





(b) Calculations



(i) Calculate the amount, in mol, of carbon dioxide produced in the decomposition.

amount of CO_2 = mol [1]

(ii) Calculate the mass of magnesium carbonate in **FB 3**.

mass of MgCO_3 = g [1]

(iii) Calculate the percentages by mass of magnesium carbonate and sodium carbonate in **FB 3**.

percentage by mass of MgCO_3 = %

percentage by mass of Na_2CO_3 = %
[1]

(c) (i) Add a few drops of water to the cool residue in the crucible.
Use universal indicator to test the pH of the solution formed.
Tick (✓) one box to show the direction of the temperature change.

pH =

temperature goes up

temperature goes down

[1]

(ii) Use these observations and the information about the thermal decomposition of magnesium carbonate to write an equation for the reaction in (c)(i). Include state symbols and the sign of ΔH .

..... [2]

(iii) Suggest how you would show that sodium carbonate had not decomposed during the reaction in (a). State the reagent(s) and observations.

Do not carry out your test.

.....
..... [2]

[Total: 13]





Qualitative Analysis

For each test you should record all your observations in the spaces provided.

Examples of observations include:

- colour changes seen
- the formation of any precipitate and its solubility (where appropriate) in an excess of the reagent added
- the formation of any gas and its identification (where appropriate) by a suitable test.

You should record clearly at what stage in a test an observation is made.

Where no change is observed, you should write 'no change'.

Where reagents are selected for use in a test, the name or correct formula of the element or compound must be given.

If any solution is warmed, a boiling tube must be used. If a solid is heated, a hard-glass test-tube must be used.

Rinse and reuse test-tubes and boiling tubes where possible.

No additional tests should be attempted.

3 **FB 4** is a mixture of two salts that each contain one cation and one anion.
All the ions present are in the Qualitative analysis notes.

(a) Place a small spatula measure of **FB 4** into a hard-glass test-tube. Heat the tube gently at first and then more strongly.

Record all your observations and identify any gas given off.

.....
.....
.....
.....
.....

[4]





(b) To a 5 cm depth of distilled water in a boiling tube, add a spatula measure of **FB 4**. Shake the tube to dissolve the **FB 4**.

(i) Carry out the following tests using a 1 cm depth of this **FB 4** solution in a test-tube for each test. Record your observations in Table 3.1.

Table 3.1

<i>test</i>	<i>observations</i>
Test 1 Add aqueous sodium hydroxide, then transfer the mixture into a boiling tube, add a piece of aluminium foil and heat gently.	
Test 2 Add an equal volume of dilute nitric acid, then add a few drops of aqueous silver nitrate.	
Test 3 Add aqueous barium chloride or barium nitrate, then add dilute nitric acid.	
Test 4 Add aqueous sodium carbonate dropwise with shaking until in excess.	

[5]

(ii) Use your observations in Table 3.1 to identify two anions which **must** be present in **FB 4**.

..... [2]





DO NOT WRITE IN THIS MARGIN

(iii) Carry out further tests to confirm or identify which two cations are present in **FB 4**. Record the reagents and conditions needed, your observations and your conclusions in a suitable table.

[5]

[Total: 16]





Qualitative analysis notes

1 Reactions of cations

cation	reaction with	
	NaOH(aq)	NH ₃ (aq)
aluminium, Al ³⁺ (aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH ₄ ⁺ (aq)	no ppt. ammonia produced on warming	—
barium, Ba ²⁺ (aq)	faint white ppt. is observed unless [Ba ²⁺ (aq)] is very low	no ppt.
calcium, Ca ²⁺ (aq)	white ppt. unless [Ca ²⁺ (aq)] is very low	no ppt.
chromium(III), Cr ³⁺ (aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu ²⁺ (aq)	pale blue ppt. insoluble in excess	pale blue ppt. soluble in excess giving dark blue solution
iron(II), Fe ²⁺ (aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe ³⁺ (aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg ²⁺ (aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn ²⁺ (aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn ²⁺ (aq)	white ppt. soluble in excess	white ppt. soluble in excess

2 Reactions of anions

anion	reaction
carbonate, CO ₃ ²⁻	CO ₂ liberated by dilute acids
chloride, Cl ⁻ (aq)	gives white ppt. with Ag ⁺ (aq) (soluble in NH ₃ (aq))
bromide, Br ⁻ (aq)	gives cream/off-white ppt. with Ag ⁺ (aq) (partially soluble in NH ₃ (aq))
iodide, I ⁻ (aq)	gives pale yellow ppt. with Ag ⁺ (aq) (insoluble in NH ₃ (aq))
nitrate, NO ₃ ⁻ (aq)	NH ₃ liberated on heating with OH ⁻ (aq) and Al foil
nitrite, NO ₂ ⁻ (aq)	NH ₃ liberated on heating with OH ⁻ (aq) and Al foil; decolourises acidified aqueous KMnO ₄
sulfate, SO ₄ ²⁻ (aq)	gives white ppt. with Ba ²⁺ (aq) (insoluble in excess dilute strong acids); gives white ppt. with high [Ca ²⁺ (aq)]
sulfite, SO ₃ ²⁻ (aq)	gives white ppt. with Ba ²⁺ (aq) (soluble in excess dilute strong acids); decolourises acidified aqueous KMnO ₄
thiosulfate, S ₂ O ₃ ²⁻ (aq)	gives off-white/pale yellow ppt. slowly with H ⁺





3 Tests for gases

gas	test and test result
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater
hydrogen, H_2	'pops' with a lighted splint
oxygen, O_2	relights a glowing splint

4 Tests for elements

element	test and test result
iodine, I_2	gives blue-black colour on addition of starch solution

Important values, constants and standards

molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
Faraday constant	$F = 9.65 \times 10^4 \text{ C mol}^{-1}$
Avogadro constant	$L = 6.022 \times 10^{23} \text{ mol}^{-1}$
electronic charge	$e = -1.60 \times 10^{-19} \text{ C}$
molar volume of gas	$V_m = 22.4 \text{ dm}^3 \text{ mol}^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0 \text{ dm}^3 \text{ mol}^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18 \text{ kJ kg}^{-1} \text{ K}^{-1}$ (4.18 J g ⁻¹ K ⁻¹)





The Periodic Table of Elements

1		2		Group																		
				1		2																
				H		He																
				hydrogen 1.0		helium 4.0																
Key	atomic number	atomic symbol	name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Li	3	4	Be	beryllium 9.0																		
Na	11	12	Mg	magnesium 24.3	3	4	5	6	7	8	9	10	11	12								
K	19	20	Ca	calcium 40.1	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
Rb	37	38	Sr	strontium 87.6	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54		
Cs	55	56	Ba	barium 137.3	57-71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86		
Fr	87	88	Ra	radium —	89-103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118		
Key																						
atomic symbol relative atomic mass																						
La	57	58	Ce	cerium 140.1	59	Pr	praseodymium 140.9	60	Nd	Pm	promethium —	61	Sm	europium 152.0	63	Gd	Dy	Ho	Tm	Er	Yb	
Ac	89	90	Th	thorium 232.0	91	Pa	protactinium 231.0	92	Np	Pu	plutonium 238.0	93	Am	americium —	94	Cm	Bk	Cf	Es	Md	No	Lr
lanthanoids																						
actinoids																						

lanthanoids	La	57	58	Ce	cerium 140.1	59	Pr	praseodymium 140.9	60	Nd	neodymium 144.2	61	Pm	promethium —	62	Sm	europium 152.0	63	Eu	Gd	Dy	Ho	Tm	Er	Yb	Lu	Yttrium 175.0																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
actinoids	Ac	89	90	Th	thorium 232.0	91	Pa	protactinium 231.0	92	Np	neptunium 238.0	93	Am	americium —	94	Cm	curium —	95	Bk	berkelium —	96	Cf	californium —	97	Es	einsteinium —	98	Fm	fermium —	99	Md	mendelevium —	100	Tm	thulium 167.3	101	Er	erbium 168.9	102	No	neobrium —	103	Lr	lawrencium —	104	Yb	ytterbium 173.1	105	Lu	lutetium 175.0	106	Y	yttrium 89	107	Yt	yttrium 89	108	Yt	yttrium 89	109	Yt	yttrium 89	110	Yt	yttrium 89	111	Yt	yttrium 89	112	Yt	yttrium 89	113	Yt	yttrium 89	114	Yt	yttrium 89	115	Yt	yttrium 89	116	Yt	yttrium 89	117	Yt	yttrium 89	118	Yt	yttrium 89	119	Yt	yttrium 89	120	Yt	yttrium 89	121	Yt	yttrium 89	122	Yt	yttrium 89	123	Yt	yttrium 89	124	Yt	yttrium 89	125	Yt	yttrium 89	126	Yt	yttrium 89	127	Yt	yttrium 89	128	Yt	yttrium 89	129	Yt	yttrium 89	130	Yt	yttrium 89	131	Yt	yttrium 89	132	Yt	yttrium 89	133	Yt	yttrium 89	134	Yt	yttrium 89	135	Yt	yttrium 89	136	Yt	yttrium 89	137	Yt	yttrium 89	138	Yt	yttrium 89	139	Yt	yttrium 89	140	Yt	yttrium 89	141	Yt	yttrium 89	142	Yt	yttrium 89	143	Yt	yttrium 89	144	Yt	yttrium 89	145	Yt	yttrium 89	146	Yt	yttrium 89	147	Yt	yttrium 89	148	Yt	yttrium 89	149	Yt	yttrium 89	150	Yt	yttrium 89	151	Yt	yttrium 89	152	Yt	yttrium 89	153	Yt	yttrium 89	154	Yt	yttrium 89	155	Yt	yttrium 89	156	Yt	yttrium 89	157	Yt	yttrium 89	158	Yt	yttrium 89	159	Yt	yttrium 89	160	Yt	yttrium 89	161	Yt	yttrium 89	162	Yt	yttrium 89	163	Yt	yttrium 89	164	Yt	yttrium 89	165	Yt	yttrium 89	166	Yt	yttrium 89	167	Yt	yttrium 89	168	Yt	yttrium 89	169	Yt	yttrium 89	170	Yt	yttrium 89	171	Yt	yttrium 89	172	Yt	yttrium 89	173	Yt	yttrium 89	174	Yt	yttrium 89	175	Yt	yttrium 89	176	Yt	yttrium 89	177	Yt	yttrium 89	178	Yt	yttrium 89	179	Yt	yttrium 89	180	Yt	yttrium 89	181	Yt	yttrium 89	182	Yt	yttrium 89	183	Yt	yttrium 89	184	Yt	yttrium 89	185	Yt	yttrium 89	186	Yt	yttrium 89	187	Yt	yttrium 89	188	Yt	yttrium 89	189	Yt	yttrium 89	190	Yt	yttrium 89	191	Yt	yttrium 89	192	Yt	yttrium 89	193	Yt	yttrium 89	194	Yt	yttrium 89	195	Yt	yttrium 89	196	Yt	yttrium 89	197	Yt	yttrium 89	198	Yt	yttrium 89	199	Yt	yttrium 89	200	Yt	yttrium 89	201	Yt	yttrium 89	202	Yt	yttrium 89	203	Yt	yttrium 89	204	Yt	yttrium 89	205	Yt	yttrium 89	206	Yt	yttrium 89	207	Yt	yttrium 89	208	Yt	yttrium 89	209	Yt	yttrium 89	210	Yt	yttrium 89	211	Yt	yttrium 89	212	Yt	yttrium 89	213	Yt	yttrium 89	214	Yt	yttrium 89	215	Yt	yttrium 89	216	Yt	yttrium 89	217	Yt	yttrium 89	218	Yt	yttrium 89	219	Yt	yttrium 89	220	Yt	yttrium 89	221	Yt	yttrium 89	222	Yt	yttrium 89	223	Yt	yttrium 89	224	Yt	yttrium 89	225	Yt	yttrium 89	226	Yt	yttrium 89	227	Yt	yttrium 89	228	Yt	yttrium 89	229	Yt	yttrium 89	230	Yt	yttrium 89	231	Yt	yttrium 89	232	Yt	yttrium 89	233	Yt	yttrium 89	234	Yt	yttrium 89	235	Yt	yttrium 89	236	Yt	yttrium 89	237	Yt	yttrium 89	238	Yt	yttrium 89	239	Yt	yttrium 89	240	Yt	yttrium 89	241	Yt	yttrium 89	242	Yt	yttrium 89	243	Yt	yttrium 89	244	Yt	yttrium 89	245	Yt	yttrium 89	246	Yt	yttrium 89	247	Yt	yttrium 89	248	Yt	yttrium 89	249	Yt	yttrium 89	250	Yt	yttrium 89	251	Yt	yttrium 89	252	Yt	yttrium 89	253	Yt	yttrium 89	254	Yt	yttrium 89	255	Yt	yttrium 89	256	Yt	yttrium 89	257	Yt	yttrium 89	258	Yt	yttrium 89	259	Yt	yttrium 89	260	Yt	yttrium 89	261	Yt	yttrium 89	262	Yt	yttrium 89	263	Yt	yttrium 89	264	Yt	yttrium 89	265	Yt	yttrium 89	266	Yt	yttrium 89	267	Yt	yttrium 89	268	Yt	yttrium 89	269	Yt	yttrium 89	270	Yt	yttrium 89	271	Yt	yttrium 89	272	Yt	yttrium 89	273	Yt	yttrium 89	274	Yt	yttrium 89	275	Yt	yttrium 89	276	Yt	yttrium 89	277	Yt	yttrium 89	278	Yt	yttrium 89	279	Yt	yttrium 89	280	Yt	yttrium 89	281	Yt	yttrium 89	282	Yt	yttrium 89	283	Yt	yttrium 89	284	Yt	yttrium 89	285	Yt	yttrium 89	286	Yt	yttrium 89	287	Yt	yttrium 89	288	Yt	yttrium 89	289	Yt	yttrium 89	290	Yt	yttrium 89	291	Yt	yttrium 89	292	Yt	yttrium 89	293	Yt	yttrium 89	294	Yt	yttrium 89	295	Yt	yttrium 89	296	Yt	yttrium 89	297	Yt	yttrium 89	298	Yt	yttrium 89	299	Yt	yttrium 89	300	Yt	yttrium 89	301	Yt	yttrium 89	302	Yt	yttrium 89	303	Yt	yttrium 89	304	Yt	yttrium 89	305	Yt	yttrium 89	306	Yt	yttrium 89	307	Yt	yttrium 89	308	Yt	yttrium 89	309	Yt	yttrium 89	310	Yt	yttrium 89	311	Yt	yttrium 89	312	Yt	yttrium 89	313	Yt	yttrium 89	314	Yt	yttrium 89	315	Yt	yttrium 89	316	Yt	yttrium 89	317	Yt	yttrium 89	318	Yt	yttrium 89	319	Yt	yttrium 89	320	Yt	yttrium 89	321	Yt	yttrium 89	322	Yt	yttrium 89	323	Yt	yttrium 89	324	Yt	yttrium 89	325	Yt	yttrium 89	326	Yt	yttrium 89	327	Yt	yttrium 89	328	Yt	yttrium 89	329	Yt	yttrium 89	330	Yt	yttrium 89	331	Yt	yttrium 89	332	Yt	yttrium 89	333	Yt	yttrium 89	334	Yt	yttrium 89	335	Yt	yttrium 89	336	Yt	yttrium 89	337	Yt	yttrium 89	338	Yt	yttrium 89	339	Yt	yttrium 89	340	Yt	yttrium 89	341	Yt	yttrium 89	342	Yt	yttrium 89	343	Yt	yttrium 89	344	Yt	yttrium 89	345	Yt	yttrium 89	346	Yt	yttrium 89	347	Yt	yttrium 89	348	Yt	yttrium 89	349	Yt	yttrium 89	350	Yt	yttrium 89	351	Yt	yttrium 89	352	Yt	yttrium 89	353	Yt	yttrium 89	354	Yt	yttrium 89	355	Yt	yttrium 89	356	Yt	yttrium 89	357	Yt	yttrium 89	358	Yt	yttrium 89	359